RESEARCH ARTICLE

INTERNATIONAL JOURNAL OF KINANTHROPOMETRY

DOI: 10.34256/ijk2324

Anthropometric Measures of Elite Indian Archer: Identification of Features for Talent Development

Jayashree Mazumder [1, *]

[1] IISER , Department of Humanities and Social Sciences, Knowledge city, Sector 81, Mohali, Punjab- 140306, India
* Corresponding authors email: jmazumder.91@gmail.com
DOI: https://doi.org/10.34256/ijk2324
Received: 15-08-2023; Revised: 28-11-2023; Accepted: 11-12-2023; Published: 30-12-2023

Resumen

Introducción: El motivo de este estudio fue determinar características antropométricas que pudieran instituir el tipo de físico y tipo corporal requerido para sobresalir en el tiro con arco. **Métodos:** Se estudiaron 33 arqueros indios de élite, tanto hombres como mujeres, de nivel nacional e internacional. Se recopiló de los jugadores tanto información demográfica mediante el método de entrevista como medidas antropométricas. Se calcularon además varios índices y luego se correlacionaron con el rendimiento de los jugadores en eventos de 70 y 50 metros utilizando arco recurvo y compuesto respectivamente con la ayuda de la correlación de Pearson. **Resultados:** La edad promedio de los arqueros indios fue de 18,3±1,3 años. La altura y el peso promedio de los arqueros fueron 167,2 cm (± 6,9) y 63,2 kg (± 10,2). El IMC promedio de los Arqueros fue de 22,5 (± 3,1 kg/m2). Estadísticamente, se observó una correlación positiva entre la puntuación individual y el peso del arco utilizado. El peso, a su vez, tuvo correlación con el índice de la mano, el índice del pie y la robustez. **Conclusión:** El presente estudio se ha centrado en todos los parámetros morfológicos posibles necesarios para sobresalir en el tiro con arco y los resultados muestran que todos los individuos tenían brazos largos, pechos estrechos y manos largas, lo que aumentaba su ventaja en el juego. Este es también el primer tipo de estudio en un frente científico que se ha centrado en los parámetros morfológicos necesarios para sobresalir en el tiro con arco.

Palabras Clave: India, IMC, Índices, Valor p, Actores nacionales, Actores internacionales

Abstract

Introduction: The motive of this study was to determine anthropometric characteristics which could institute the type of physique and body type required to excel in archery. **Methods:** 33 elite Indian archers, both men and women, from National and International levels, were studied. Demographic information using the interview method and anthropometric measurements was collected from the players. Various indices were further calculated and then correlated with the players' performance in 70m and 50m events using recurve and compound bow, respectively, with the help of Pearson correlation. **Results:** The average age of the Indian Archers was 18.3±1.3 years. The average height and weight of the Archers were 167.2 cm (± 6.9) and 63.2kg (± 10.2). The average BMI of the Archers was 22.5 (± 3.1 kg/m2). Statistically, a positive correlation was seen between the individual score and the poundage of the bow used. Poundage, in turn, correlated with the hand index, foot index, and robusticity. **Conclusion:** The present study has focused on all possible morphological parameters required to excel in archery, and the results depict that all individuals had long arms, narrow chests, and long hands, which added to their advantage in the game. This is also the first scientific study that has focused on the morphological parameters required for excelling in archery.

Keywords: India, BMI, indices, P-value, National players, International players

Introduction

Every individual is unique in their own way, and these differences are the core factors that influence the performance of any well-known skill. Some of such factors are mainly dependent on the genetic background such as growth and on the other hand some factors like physical activity, nutrition etc. are dependent on the environmental factors and thus influence them. Body performing skills are mainly influenced by individual differences such as body

structure, size and growth (Okely, Booth, & Chey, 2004; Peters, 1993). Sports science has undergone huge changes and has contributed to the development of various aspects of sports with special reference in competitive sports. The use of anthropometric measurement also has gained importance in reflecting the body type and fitness which play a core role in the determination of performance and success on players (Dusan, Dragan, & Milos, 2002; Mermier, Janot, Parker, & Swan, 2000).

Identification of sports talents is one of the main factors in determining players' success with respect to the game. To achieve the best performance in related skills at international levels, it is very important to survey various anthropometric measurements and body somatotypes (Mohamed et al., 2009; Vaeyens, Lenoir, Williams, & Philippaerts, 2008). Recent studies have shown that in most sports, there is a close and direct relationship between physiological and anthropometric measurements (Mohamed et al., 2009). However, this relationship is strong and could guarantee the advancement of an athlete in their professional career using proper technique (Mohamed et al., 2009; Vaeyens et al., 2008). Studies conducted across different sports fields have shown that in most sports, a close relationship exists between anthropometric characteristics and physiological measurements (Kian, Ghomshe, & Norang, 2013; Mermier et al., 2000). Thus, a strong relationship could probably guarantee a player's advantage in the professional field by using proper technique and equipment (Jin & Shen, 2004), and in this context, archery could also be included. Accordingly, for swimmers, anthropometric factors like body surface, length of limbs (arm and leg), the weight of the body, height and age have a direct as well as positive correlation with the swimming time; thereby enhancing their swimming record (Knechtle, Baumann, Knechtle, & Rosemann, 2010). In the game of archery, various anthropometric factors such as chest shape, arm size, hand size etc. play a very important role in relation to the performance of the individual in this game. Since, archery is a skill game, as it uses the specific techniques, the importance of anthropometric features play a pivot role in attaining greater achievement (Eckert & Wendt, 2013). Again, in the game of archery upper body limbs especially factors like shoulder, elbow, wrist and fingers play a major role because the endurance and muscular strength affect the performance of the archer (Eckert & Wendt, 2013; Shams, Matinhomaie, & Peeri, 2015). According to all the studies know, there has been no research conducted to find out the body type required for a talent search in this game. The purpose of this study was to investigate the body type of elite Indian archers participating in various international and national official tournaments. This type of research provides us with the factors that could help in the selection of players in the initial stage of the game so as to provide proper coaching in accordance with their body type.

Materials and Methods

Subjects

Thirty-three elite male and female Indian archers (Table 1) selected for the Asia Cup trial 2016 from all over the country with professional physical activity participated voluntarily in this study. The players were free from any type of medication and had no history of injury or disease before or during this study. Sports Authority of India passed the current work, Delhi (S.A.I.), which permitted the procedures and the study protocols, which were fully explained to all subjects and coaches before and only upon their acknowledgement a written consent form had been signed where the entire research details of the study were mentioned.

Ethical permission

In India S.A.I. (Sports Authority of India), is the supreme government organization who conducts research in the discipline of sports. The research proposal was passed by S.A.I (New Delhi, Headquarters). Prior the research, the subjects and the coach were informed about the work and only upon agreeing the consent form was signed by the respective players and their coaches and in case of a minor, only the coach had signed the consent form.

Data collection method

After coordination with the S.A.I. Rohtak's regional centre and satisfying the coaches and their archers with personal informed written consent, data collection from the archers had started which was done on the day before the match. There were two categories in matters of equipment used i.e. recurve and compound bow. Scores at 70m and 50m for recurve and compound bow respectively were taken and the poundage of the bows used by the archers was recorded.

Anthropometric Measurements

The anthropometric measurements were measured as per the international protocol described in the International Society for the Advancement of Kinanthropometry manual (ISAK). 15 anthropometric measurements were taken and then various indices were calculated accordingly. An anthropometric set was used to measure all the

parameters whereas, the standing height was measured with the help of stadiometer (up to 1mm) and body mass was measured with an electronic weighing machine. Skinfold thickness was measured with the help of a Harpenden Skinfold calliper. An anthropometric tape was used for measuring girth whereas sliding calliper was used to measure the bone width.

Indices

11 indices were calculated (Singh & Bhasin, 2004) to find the dimension of the body part and its correlation with the game. These were-

Skelic index = (Physiognomic leg length (cm))/(Sitting height (cm)) * 100 [Vandervael, 1964]

Physiognomic leg length = (Height (cm))/(Sitting height (cm)) * 100

Robusticity = Height (cm)-{Chest Girth (cm)+ Weight (kg)} [Tschernorutzky]

Ape Index = (Arm Span (cm))/(Height (cm))*100 [Vitruvius]

Chest Girth Stature Index (CGS Index) = (Chest Girth (cm))/(Height (cm)) *100 [Martin and Seller]

Thoracic Index = (Chest Depth (cm))/(Chest Breadth (cm))*100 [Olivier, 1969]

Shoulder Hip Index (S.H. Index) = (Bicristal breadth (cm))/(Biacromium breadth (cm))*100 [Vallois]

Sitting Height vertex Index = (Sitting height (cm))/(Height (cm))*100 [Brugsch]

Biacromial breadth Stature Index (B.S. Index) = (Biacromium breadth (cm))/(Height (cm))*100 [Brugsch]

Arm Index = (Forearm length (cm))/(Upper arm length (cm))*100 [Olivier, 1969]

Hand Index = (Handbreadth (cm))/(Hand length (cm))*100 [Martin and Seller]

Foot Index = (Foot-breadth (cm))/(Foot length (cm))*100 [Olivier, 1969]

Body density and fat percent

Durnin & Womersley (1974) technique was followed by measuring the body fat percent, whereas the body density was derived from the equation given by.

Statistics

The statistical analysis was done using SPSS software 17.1 version.

Results

Total 33 elite Indian archers among which 16 were female and 17 were male with an average professional experience in archery for 6±2.2 years had participated in this study (Table 1).

Table 1. Descriptive statistics showing the age, professional experience, height, weight, BMI and fat % of Indian archers

Sample	Parameters	Age (years)	Training (Year)	Height (cm)	Weight (kg)	BMI (kg/m^2)	Fat %
Total (**n=33**)	Mean	18.3	6	167.2	63.1	22.5	5.3
	Std. Dev	1.3	2.2	6.9	10.1	3.1	1.8
	Minimum	16	3	154.3	48.5	16.7	1.1
	Maximum	21	12	181.4	88.6	32.7	9.3
Male (**n=17**)	Mean	18.4	6.5	170.7	66.1	22.6	4.2
	Std. Dev	1.5	2.6	6.8	10.1	2.9	1.5
	Minimum	16	3	160.0	49	16.7	1.1
	Maximum	21	12	181.4	88.6	28.7	6.3
Female (**n=16**)	Mean	18.2	5.4	163.5	60.1	22.4	6.6
	Std. Dev	1.5	1.4	4.8	9.3	3.3	1.7
	Minimum	16	4	154.3	49	18.9	3.9
	Maximum	21	8.5	173	87	32.7	9.3

Table 2. Body type of Indian Archers

Indices	Categorization	Total Sample	Gender	
			Female	Male
		Count	Count	Count
Training Level		33	16	17
	International	22	12	10
	National	11	4	7
Shoulder Hip Index		33	16	17
	Medium	6	6	0
	Rectangle	8	4	4
	Trapeze	19	6	13
Sitting height Index		33	16	17
	Macroskelic	15	10	5
	Mesatiskelic	11	3	8
	Brachyskelic	7	3	4
Biacromium breadth Stature Index		33	16	17
	Broad Shoulder	8	2	6
	Medium Shoulder	8	5	3
	Narrow Shoulder	17	9	8
Ape Index		33	16	17
	Monkey Arm	33	16	17
Arm Index		33	16	17
	Long Forearm	33	16	17
Hand Index		33	16	17
	Dolichocheir	9	3	6
	Hyperdolichocheir	20	12	8
	Mesocheir	4	1	3
Thoracic Index		33	16	17
	Narrow Chest	33	16	17
Chest Girth Stature Index		33	16	17
	Broad Chest	2	1	1
	Medium Chest	19	10	9
	Narrow Chest	12	5	7
Robusticity		33	16	17
	Hypersthenic	20	9	11
	Normasthenic	7	5	2
	Asthenic	6	2	4
Skelic Index		33	16	17
	Hypermacroskelic	4	2	2
	Brachyskelic	1	0	1
	Sub-Brachyskelic	3	3	0
	Mesatiskelic	8	2	6
	Sub-Macroskelic	9	4	5
	Makroskelic	8	5	3
Foot Index		33	16	17
	Dolichopod	17	11	6
	Mesopod	11	5	6
	Brachypod	5	0	5

The age of the archers is 18.3 ± 1.3 years, with an average height of 167.2 ± 6.9 cm., and a body weight of about 63.1 ± 10.1 kg. Their BMI was normal and calculated to be 22.5±3.1 kg/m2. According to table 1, the height of male was recorded to be 170.7 ± 6.8 cm., with an average body weight of 66.1 ± 10.1 kg., BMI being 22.6 ± 2.9 kg/m2 and fat percent being 4.2 ± 1.5 %. Females had an average height of 163.5 ± 4.8 cm., weight 60.1 ± 9.3 kg., BMI 22.4 ± 3.3 kg/m2 and fat percent was recorded to be 6.6 ± 1.7 %. Accordingly, the study shows that the sex of the individual had no effect on the BMI, whereas the fat percent varied slightly and was more among females when compared to their male counterparts but it could be due to hormones which promote more fat in females.

Table 2 shows the body type of the players. In this table, it was found that Skelic index (Leg length), chest index (chest shape in relation to height), trunk shape, robusticity, trunk height, shoulder shape and foot shape showed variation among the players (i.e. these factors did not follow a fixed pattern thereby could be possible not to have any implication with the game). Indices such as arm span, forearm length and thoracic index show that the population has the unique characters.

Thus, archers which longer arm span, longer forearm and narrow chest were best suitable for this game as these features add to their advantage. On the basis of these three indices, the total group of players irrespective of gender shared a common body type as in having longer limbs and a narrow chest. Thus, it could be said that players with long upper limbs and flat chest are best meant to be in the game of archery. Hand size when examined it was found that the players ranged from very long hand to medium sized hands. Thus, players with the shorthand could be at a disadvantageous side for this game. There seems to exist a kind of homogeneity among the archers in terms of arm span, forearm length and the thoracic shape thus, only individuals with this feature could be more successful in this game.

Table 3. Descriptive Statistics of the indices used

Variables	Mean	Std. Deviation	Minimum	Maximum
Score	624.21	42.80	529	690
Poundage	44.82	8.11	26	60
S.H. Index	67.13	8.91	52.9	98.7
Sitting Height Index	52.06	1.69	48.7	56.02
B.S. Index	21.40	2.13	13.69	24.73
Ape Index	104.79	2.42	100.12	110.6
Arm Index	139.74	6.06	129.23	153.79
Hand Index	40.41	2.71	33.17	45.21
Thoracic Index	65.66	5.55	55.45	78.63
CGS Index	51.78	4.12	41.43	64.84
Robusticity	17.59	14.66	-29.50	51.20
Skelic Index	92.24	6.20	78.51	105.32
Foot Index	37.32	4.10	22.73	44.29

Table 3 shows the mean and standard deviation of various indices calculated along with the performance record (scores at 70m and 50m tournaments using the recurve and compound bow respectively) and poundage of the bows used by the archers. The average score of the players was 624.21 points, with the lowest score being 529 points and highest being 690 points. The highest poundage of bow used was of 60 pounds and lowest poundage was 26 pounds and on an average, most players used bows with 44.82±8.11 pounds.

Table 4 shows the Pearson correlation test. According to the study a high correlation is seen between the score and the poundage of bow used and poundage, in turn, shows a high positive correlation with hand size and foot index (P>0.05). Thus, archers with longer hands are a better fit for the game as it would help in providing proper tension to the bowstring and long foot would help in maintaining balance during the shooting posture. Poundage has a negative correlation with robusticity index (P>0.05), thereby denoting more strength is required and thereby more robust body is a better fit for the game.

Table 4. Correlations matrix between various indices, score and poundage of bow used.

PARAMETERS		Score	Poundage	S.H. Index	Sitting- Height Index	B.S. Index	Ape Index	Arm Index	Hand Index	Thoracic Index	CGS Index	Robusticity	Skelic Index	Foot Index
Score	Pearson Correlation	1	.608**	-.054	-.018	-.102	-.188	-.041	.296	-.248	-.167	.078	.012	.305
	Sig. (2-tailed)		.000	.764	.920	.571	.296	.820	.095	.163	.354	.668	.947	.084
Poundage	Pearson Correlation		1	-.006	.137	.027	.006	-.008	.420*	-.210	.184	-.379*	-.140	.370*
	Sig. (2-tailed)			.974	.447	.883	.973	.965	.015	.242	.306	.029	.437	.034
S.H. Index	Pearson Correlation			1	-.156	-.745**	.045	-.390*	-.171	-.048	.200	-.076	.154	-.301
	Sig. (2-tailed)				.385	.000	.805	.025	.342	.792	.265	.673	.394	.088
Sitting Height Index	Pearson Correlation				1	.179	-.434*	.217	.119	.157	.175	-.155	-.999**	.073
	Sig. (2-tailed)					.320	.012	.225	.508	.383	.329	.390	.000	.685
B.S. Index	Pearson Correlation					1	.206	.173	.282	.119	.188	-.258	-.172	.089
	Sig. (2-tailed)						.250	.335	.112	.510	.296	.147	.339	.621
Ape Index	Pearson Correlation						1	-.082	-.046	-.007	.156	-.236	.439*	-.228
	Sig. (2-tailed)							.649	.798	.968	.386	.186	.011	.203
Arm Index	Pearson Correlation							1	-.193	-.001	-.146	.135	-.214	.044
	Sig. (2-tailed)								.281	.995	.418	.452	.233	.809
Hand Index	Pearson Correlation								1	.073	.034	-.174	-.124	.467**
	Sig. (2-tailed)									.686	.853	.332	.492	.006
Thoracic Index	Pearson Correlation									1	-.016	.041	-.155	-.089
	Sig. (2-tailed)										.930	.821	.390	.621
CGS Index	Pearson Correlation										1	-.907**	-.176	-.016
	Sig. (2-tailed)											.000	.327	.928
Robusticity	Pearson Correlation											1	.158	-.103
	Sig. (2-tailed)												.381	.570
Skelic Index	Pearson Correlation												1	-.082
	Sig. (2-tailed)													.648
Foot Index	Pearson Correlation													1
	Sig. (2-tailed)													

**. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed).

In table 3 the statistical analysis of the various indices used have been described and table 4 shows the correlation between the score and the indices calculated. The average score of the players was 624.21± 42.8. There seems to be a positive correlation between the score with the poundage of bow used (0.608 at P>0.01). This is very important as higher poundage help in more accuracy in shooting and with poundage, factors such as hand index and foot index, show a positive relation (0.42 and 0.37 at P>0.05). Thus players with longer hands needed to use a bow with higher poundage which could give more accuracy and longer foot could help in proper balancing of the bow during the full draw position. The average poundage of the bow used was 44.82 ± 8.11. The hand index had an average value of 40.41 ± 2.71 and the foot index had an average value of 37.32 ± 4.1 (Table 3).

There was a negative correlation of poundage of bow with robusticity (-0.379, P> 0.05) where the average value or robusticity was17.59 ± 14.66 and with a minimum value of -29.50 and the maximum value of 51.2. This denotes that more robust body is a better fit for the game as people with such body type could prove with the necessary strength required by the player to pull the string with higher poundage to full draw position. Other correlations have also been found between the indices but the main motive of this study was to find the correlation of the indices with the score of the players (Table 4).

Discussion

In the contemporary world competitions between nations has increased to win medals in the international platform such as the world cups and the Olympic games (McCann, 2008). A number of countries today are trying to structurally develop methods which could help in identification of talent in an individual at the initial stage of life (Pankhurst & Collins, 2013). Such studies are primarily focused on the ability and the functionality of the individual to have a benefit in a certain sport (Pankhurst & Collins, 2013).

In the study, it was seen that players with longer arms and narrow chests were best fit for the game. Again, it was observed that longer arms, had a larger draw length, which in turn had a positive relationship with the poundage of bow used. According to a study conducted by Kian and his colleagues (2013), anthropometric measurements like the arm length, wrist girth, length of three fingers (index, middle and ring finger) and size of palm play an integral part in archery in relation with the drawing ability of the bowstring. Another study conducted by Shams, et al. (2015) on the Elite Asian Archers; found a strong relationship of the anthropometric characters such as finger lengths, wrist breadth etc with the performance of the archers who were participating in Asia Grand Prix in Bangkok Thailand 2013.

The performance of a player is mostly affected by their anatomical and physiological features, thus a proper understanding of their physical and anthropometric characteristics is very necessary as it could also affect the performance of athletes (Mermier et al., 2000). The study conducted by Shams, et al. (2015) shows a significant relationship between the size of the finger on bowstring and subject's 70m performance record. Other variables (the palm, arm and wrist length) calculated did not show any significant relationship with 70m performance record. In the study, the individual's height and weight had no significant relationship with their performance but there seemed to be some variation in anthropometric features when the two sex were compared. It has been reported that the growth of body parts in the embryonic stage shows that sex differences in the proportion of the second finger to the fourth finger begin in the embryonic period itself and other researchers state that it is also depended upon the levels of fetal estrogen and testosterone (Kilduff, Cook, & Manning, 2011). They even stated that sex steroids have significant effects on fetal organs, thus the second to fourth finger ratio could be a predictor of performance in sport. Nevertheless, elite female athletes have a significantly lesser second to fourth finger ratio when compared with a control group of women who were non-athlete i.e. they did not participate in any form of physical activity (Longman, Stock, & Wells, 2011). In the study, it was seen that in spite of sharing same BMI value with males, the fat percentage in female was slightly higher. Women, on the other hand, have been observed to have higher fat accumulation than man due to hormonal factors (Weltman et al., 1994).

Anthropometric measurements are a simple, practical and an inexpensive method for the evaluation of the proportion, size, shape, maturity and composition of the body which helps in understanding the individual's growth, health, nutritional status and sports performance (Mermier et al., 2000). It is a very important aspect in sports to have the ability to acquire and even use the accurate information about the body and physiological properties of an athlete as the anthropometric and physiological features could offer an important prerequisite for the successful participation of the individual in each sport (Santos et al., 2010).

In archery, the dimensions and size of wrist circumference, palm and arm length seems to be important in case of holding the bow so as to have enough strength to take the bowstring and shoot it (US006125833A, 2000; US007422008BI, 2008). Professional athletes have a significant negative relation with finger ratio of the second and fourth digits while a strong correlation has been found in the analysis of the ability to run (Paul et al., 2006). Again, the second to fourth finger ratio has an association with strength (Longman et al., 2011). A study conducted on the young men and women had come to the conclusion that there was a negative correlation in the right hand between

the degree of physical activity and the second to fourth finger ratio (Hönekopp, T. Manning, & Müller, 2006). Shams, et al. (2015) in their study have found the factors which have a significant correlation with the performance of an archer as it would play a major role in arrow down. These factors were related to the archer's 70m records, a positive correlation was seen between them. The motive of their study was to relate the communication of body parts with archery biomechanical features as in the last moment a drop shot from the bow so as to steer the beam to hit the target, longer fingers had an advantage as it enhanced the accuracy and strength of targeting. Thus, it was an important factor that could be used in the selection of talent and athletes interested in reaches higher levels.

In the present study, anthropometric measurements were then put in various formulas to study the desired body type for archery. In the present study, various indices were calculated which included the length and dimension of both upper and lower limbs along with the trunk region. The calculated value for the indices depicts homogeneity among the players. During this study, the players were among the top archers from India selected for the Asia cup trial 2016. Archers were from different parts of the country and from different ethnicity. The archers examined during this study used either compound or recurve bow. The motive of this study was to study the basic anthropometric characters required to become an elite archer irrespective of ethnicity, type of bow and gender. Therefore, it could be said that to be an elite archer, anthropometric characteristics of the individual have an added advantage for the success of the player in the game of archery and arm length and chest shape plays a very characteristic part which should be considered while individual selection on for the game.

Conclusion

To my knowledge, this is the first kind of study, which has emphasized on anthropometric features important during the selection of an archer. In general, the results of this study reveal that the anthropometric features of the top Indian male and female athletes participating in the Asian cup tournament 2016. In the present study, it was found that all the players had certain anthropometric traits in common- narrow chest, long forearm, very long to medium sized hand size. It was also seen that the arm span of all the players was comparatively more than their height. Thus, to become a perfect archer, one should have long arms and hands with a narrow chest which will enable longer draw length. Longer draw length also indicates usage of high poundage bow which enhances their score. Thereby, all the factors inter-relate with one another for a qualitative performance in archery. It was also seen that the size of the hand and foot along with body strength in pulling bowstring has a significant relationship with the poundage of the bow used and other aspects of the measurement, such as the sitting height index, shoulder hip index, biacromium breadth stature index, etc. had no relationship with the poundage of the bow . The importance of strength and muscular endurance which is related to the magnitude and size of the arm is very well found when such test is performed for a long time which results in fatigue. To conclude, the current study highlights the anthropometric factors which play a vital role in quality performance among elite Indian archers.

References

Brožek, J., Grande, F., Anderson, J.T., Keys, A. (2006). Densitometric analysis of body composition: revision of some quantitative assumptions. *Annals of the New York Academy of Sciences*, 110(1): 113–140. https://doi.org/10.1111/j.1749-6632.1963.tb17079.x

Durnin, J.V.G.A., Womersley, J. (1974). Body fat assessed from total body density and its estimation from skinfold thickness: measurements on 481 men and women aged from 16 to 72 Years. *British Journal of Nutrition*, 32(01): 77–97. https://doi.org/10.1079/BJN19740060

Dusan, U., Dragan, M., Milos, K., Slobodan J. (2002). Standard anthropometric, body composition and strength variables as predictors of jumping performance in elite junior athletes. *The Journal of Strength, Conditioning Research*, 16(2): 227-230. https://doi.org/10.1519/00124278-200205000-00009

Eckert, H., Wendt, D. (2013). Various Measures Related to Draw in Archery. *Research Quarterly. American Association for Health, Physical Education and Recreation,* 37(1): 144–147. https://doi.org/10.1080/10671188.1966.10614748

Hönekopp, J., Manning, J.T, Müller, C. (2006). Digit ratio (2D:4D) and physical fitness in males and females: Evidence for effects of prenatal androgens on sexually selected traits. *Hormones and Behavior,* 49(4): 545–549. https://doi.org/10.1016/j.yhbeh.2005.11.006

Jin, H.M., Shen, X.Z. (2004). Characteristics and assessment of IQ, nerve types and response time of shooting and Archery talents. *Sports Science Research*, 25: 65-68.

Kian, A., Ghomshe, F.T., Norang, Z. (2013). Comparing the ability of controlling the bow hand during aiming phase between two elite and beginner female compound archers: A case study. *European Journal of Experimental Biology,* 3(4): 103–111.

Kilduff, L.P., Cook, C.J., Manning, J.T. (2011). Digit ratio (2D:4D) and performance in male surfers: *Journal of Strength and Conditioning Research,* 25(11): 3175–3180. https://doi.org/10.1519/JSC.0b013e318212de8e

Knechtle, B., Baumann, B., Knechtle, P., Rosemann, T. (2010). Speed during Training and Anthropometric Measures in Relation to Race Performance by Male and Female Open-Water Ultra-Endurance Swimmers. Perceptual and Motor Skills, 111(2): 463–474. https://doi.org/10.2466/05.25.PMS.111.5.463-474

Longman, D., Stock, J.T., Wells, J.C.K. (2011). Digit ratio (2D:4D) and rowing ergometer performance in males and females. *American Journal of Physical Anthropology*, 144(3): 337–341. https://doi.org/10.1002/ajpa.21407

McCann, S. (2008). At the Olympics, everything is a performance issue. *International Journal of Sport and Exercise Psychology,* 6(3): 267–276. https://doi.org/10.1080/1612197X.2008.9671871

Mermier, C.M., Janot, J.M., Parker, D.L., Swan, J.G. (2000). Physiological and anthropometric determinants of sport climbing performance. *British Journal of Sports Medicine*, 34(5): 359. https://doi.org/10.1136/bjsm.34.5.359

Mohamed, H., Vaeyens, R., Matthys, S., Multael, M., Lefevre, J., Lenoir, M., Philippaerts, R. (2009). Anthropometric and performance measures for the development of a talent detection and identification model in youth handball. *Journal of Sports Sciences*, 27(3): 257–266. https://doi.org/10.1080/02640410802482417

Okely, A.D., Booth, M.L., Chey, T. (2004). Relationships between Body Composition and Fundamental Movement Skills among Children and Adolescents. *Research Quarterly for Exercise and Sport*, 75(3): 238–247. https://doi.org/10.1080/02701367.2004.10609157

Pankhurst, A., Collins, D. (2013). Talent Identification and Development: The Need for Coherence between Research, System, and Process. *Quest*, 65(1): 83–97. https://doi.org/10.1080/00336297.2012.727374

Paul, S.N., Kato, B.S., Hunkin, J.L., Vivekanandan, S., Spector, T.D., Fields, K.B. (2006). The Big Finger: the second to fourth digit ratio is a predictor of sporting ability in women * Commentary. British Journal of Sports Medicine, 40(12): 981–983. https://doi.org/10.1136/bjsm.2006.027193

Peters, R.H. (1993). The ecological implications of body size (Repr). *Cambridge University Press*.

Santos, D.A., Silva, A.M., Matias, C.N., Fields, D.A., Heymsfield, S.B., Sardinha, L.B. (2010). Accuracy of DXA in estimating body composition changes in elite athletes using a four-compartment model as the reference method. *Nutrition & Metabolism*, 7(1): 22.

Shams, Z., Matinhomaie, H., Peeri, M. (2015). Anthropometric measurements and dominant arm relationships with elite Asian archer's performance in 2013 year. International Journal of Biology, Pharmacy and Allied Sciences, 4(9): 5739–5738.

Singh, I.P., Bhasin, M.K. (2004). A Manual of Biological Anthropology. *Kamla-Raj Enterprise*. Delhi, India

Tentler, L.A., Kutz, B.L., du Lac Wis, F. (2000). Unites States Patent. Retrieved from https://patentimages.storage.googleapis.com/76/32/73/7dbef560821c50/US6125833.pdf

Tentler, S., & Tentler, L.A. (2008) Unites States Patent. Retrieved from https://patentimages.storage.googleapis.com/a9/5b/f6/152be606bbb5ba/US7422008.pdf

Vaeyens, R., Lenoir, M., Williams, A.M., Philippaerts, R.M. (2008). Talent Identification and Development Programmes in Sport: Current Models and Future Directions. *Sports Medicine*, 38(9): 703–714. https://doi.org/10.2165/00007256-200838090-00001

Weltman, A., Weltman, J.Y., Hartman, M.L., Abbott, R.D., Rogol, A.D., Evans, W.S., Veldhuis, J.D. (1994). Relationship between age, percentage body fat, fitness, and 24-hour growth hormone release in healthy young adults: effects of gender. *The Journal of Clinical Endocrinology & Metabolism*, 78(3): 543–548. https://doi.org/10.1210/jcem.78.3.8126124

Funding

No funding was received for conducting this study.

Conflicts of Interest

The author has no conflicts of interest to declare that they are relevant to the content of this article.

DOI: 10.34256/ijk2324